

CLAIMS:

1. Radiographic equipment comprising:
 - a source of substantially mono-energetic fast neutrons produced via the deuterium-tritium or deuterium-deuterium fusion reactions, comprising a sealed-tube or similar generator for producing the neutrons;
 - a source of X-rays or gamma-rays of sufficient energy to substantially penetrate an object to be imaged;
 - a collimating block surrounding the neutron and X-ray and gamma-ray sources, apart from the provision of one or more slots for emitting substantially fan-shaped radiation beams;
 - a detector array comprising a multiplicity of individual scintillator pixels to receive radiation energy emitted from the sources and convert the received energy into light pulses, the detector array aligned with the fan-shaped radiation beams emitted from the source collimator and collimated to substantially prevent radiation other than that directly transmitted from the sources reaching the array;
 - conversion means for converting the light pulses produced in the scintillators into electrical signals;
 - conveying means for conveying the object between the sources and the detector array;
 - computing means for determining from the electrical signals the attenuation of the neutrons and the X-ray or gamma-ray beams and to generate output representing the mass distribution and composition of the object interposed between the sources and detector array; and
- 25 display means for displaying images based on the mass distribution and the composition of the object being scanned.
2. Radiographic equipment according to claim 1, where the X-ray or gamma-ray source comprises a ^{137}Cs , ^{60}Co or similar radioisotope source having an energy of substantially 1 MeV.
- 30 3. Radiographic equipment according to claim 1, where the X-ray or gamma-ray source comprises an X-ray tube or electron accelerator producing X-rays through Bremsstrahlung on a target.

4. Radiographic equipment according to any one of the preceding claims, where the neutron source produces neutrons having substantially higher energies than the X-ray or gamma-rays from the X-ray or gamma-ray source, where the neutron and X-ray or gamma-ray sources are arranged to pass through the same slot in the collimating block and a single detector array is used, comprising individual pixels of plastic or liquid organic scintillator, where discrimination between the gamma-rays and the neutrons is made on the basis of the energy they deposit in the scintillator.

5. Radiographic equipment according to any one of claims 1 to 3, where the sources of neutrons and X-ray or gamma-rays are arranged to pass through the same slot in the collimating block and a single detector array is used comprising individual pixels of plastic or liquid organic scintillator, where the neutron and X-ray or gamma-ray sources are operated alternately.

15 6. Radiographic equipment according to any one of claims 1 to 3, where the sources of neutrons and X-ray or gamma-rays are arranged to pass through separate parallel slots in the collimator block and two detector arrays are used, one comprising individual pixels of plastic or liquid organic scintillator for the detector of the neutrons and one comprising individual pixels of plastic, liquid or inorganic scintillator for 20 detection of the X-rays or gamma-rays.

7. Radiographic equipment according to any one of claims 4 to 6 where each slot of the source and detector collimators are sufficiently wide to ensure full illumination of the detectors by the source, whilst minimising the detection of scattered radiation.

25 8. Radiographic equipment according to claim 1, further comprising a second sealed tube or similar neutron source producing neutrons via either the deuterium-tritium or deuterium-deuterium fusion reactions, where the second source uses the complementary fusion reaction to the first source.

30 9. Radiographic equipment according to claim 8, where the neutrons from the second neutron source are detected in a separate collimated detector array comprising individual pixels of plastic or liquid organic scintillator.

10. Radiographic equipment according to claim 9, where one of the first or second source of neutrons has an energy of substantially 14 MeV and the other source of neutrons has an energy of substantially 2.45 MeV.
- 5 11. Radiographic equipment according to any one of the preceding claims, where the conversion means comprises a plurality of photodiodes, wherein the scintillator material is selectable to have an emission wavelength substantially matched to the response of the photodiodes.
- 10 12. Radiographic equipment according to any one of the preceding claims, where the conversion means comprises crossed wavelength shifting fibres coupled to a multiplicity of single or multi-anode photomultiplier tubes.
- 15 13. Radiographic equipment according to claim 11 or claim 12, where the electrical signals from the conversion means are used to infer the transmission of the neutrons from the neutron source and the X-rays or gamma-rays through the object being scanned, or the transmission of the neutrons from the first neutron source, the X-rays or gamma-rays and the neutrons from the second neutron source through the object being scanned.
- 20 14. Radiographic equipment according to claim 13, where the transmissions are used to compute mass attenuation coefficient images for each pixel for display with different pixel values mapped to different colours, the image based on the mass distribution and composition inferred from these computations.
- 25 15. Radiographic equipment according to any one of the preceding claims, where the computing means comprises a computer to perform image processing and display the images on a computer screen.
- 30 16. Radiographic equipment according to claim 15, where the output is convertable to mass-attenuation coefficient images for each pixel for display on a computer screen with different pixel values mapped to different colours.
- 35 17. Radiographic equipment according to claim 16, where the mass-attenuation coefficient images are obtainable from count rates measured from the transmissions for each of the deuterium-tritium neutrons or deuterium-deuterium neutrons and X- rays or

gamma-rays, or the deuterium-tritium neutrons, deuterium-deuterium neutrons and X-rays or gamma-rays.

18. Radiographic equipment according to claim 17, where the computer is
5 operable to obtain cross section ratio images between pairs of mass attenuation
coefficient images.

19. Radiographic equipment according to claim 18, where the proportions in
which the cross section ratio images are combined are adjustable to maximise contrast
10 and sensitivity to a particular object being examined in the image.

20. Radiographic equipment according to claim 18 or claim 19, where the computer is able to perform automatic material identification based on the measured cross sections.

15 21. Radiographic equipment according to any one of the preceding claims, where the sources and the detector array are stationary and the transport mechanism is arranged such that the object is able to be moved in front of the source of neutrons.

20 22. Radiographic equipment according to any one of claims 1 to 20, where the object is stationary and the transport mechanism arranged such that the source and the detector array move in synchronicity either side of the object.

23. Radiographic equipment according to any one of claims 1 to 20, where
25 multiple sets of detectors are situated around the sources which are centrally located to allow scans of a plurality of separate objects to be acquired simultaneously.

24. Radiographic equipment according to any one of claims 1 to 20, where the sources and the detector array are able to be rotated around the object to be examined to
30 enable multiple views to be obtained.

25. Radiographic equipment according to any one of the preceding claims, where the intensity of either the deuterium-deuterium and/or deuterium-tritium neutron sources is of the order 10¹⁰ neutrons/second or as high as practically possible.

26. Radiographic equipment according to claim 11 where the scintillators are surrounded by a mask to cover at least a portion of each of the scintillators, each mask having a first reflective surface to reflect escaped light pulses back into the scintillator.